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STUDY - PILOT PERCEIVED JETTISON ENVELOPE

Albert L. Winn, et al

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13. ABSTRACT

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STUDY

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FINAL REPORT

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PROJECT OFFICER/ENGINEER

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PROJECT PILOT

JUNE 1973

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UNITED STATES ARMY AVIATION SYSTEMS TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

FOREWORD

The data contained in this report were obtained as a part of other programs being conducted at the United States Army Aviation Systems Test Activity. Pilot recognition of side force data was provided by Lt Colonel Paul G. Stringer, Major John R. Smith, and Mr. Joseph C. Watts.

ABSTRACT

The OH-6A, OH-58A, and AH-56A helicopters were evaluated to determine pilot sensed sideslip cues with respect to their influence on the jettison of external stores. The data were necessary to confirm previous studies with the UH-1C and CH-47C helicopters, and to expand the data to other helicopters and operating conditions. Tests were conducted at the United States Army Aviation Systems Test Activity, Edwards Air Force Base, California and at Yuma Proving Ground, Arizona. Additionally, data previously obtained for other test helicopters were analyzed to determine variation in static lateral-directional stability with altitude, gross weight, rotor speed, and center-of-gravity location. Results confirm that side force is the most significant cue to pilot recognition of uncoordinated flight. The pilots' evaluation of side force was consistent for all aircraft and all test cases. During this evaluation, the pilots recognized lower side force values than during the UH-1C and CH-47C evaluations. Data analysis shows helicopter side-force characteristics to be relatively independent of atmospheric or operating conditions other than airspeed and sideslip angle. Helicopter lateral-directional stability characteristics and pilot recognition of side force can be combined to predict a minimum required jettison envelope for theoretical or actual flight vehicles. This procedure can be used for early definition of problem areas and to reduce the cost and risk associated with establishing flight jettison envelopes.

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INTRODUCTION

BACKGROUND

1. The numbers and types of Army helicopters having external stores configurations have increased significantly in recent years. A majority of these stores contain explosives or materials which can be dangerous to aircraft or crew and hence must be jettisonable. Current test procedures used to obtain a jettison envelope for external stores involves actual jettison at a variety of test conditions and configurations. Although costly and time-consuming, these procedures are necessary, since there are no existing design criteria or definitions of required jettison envelopes. Development of a standardized test procedure whereby a jettison capability could be demonstrated at a predetermined condition can provide the above design guidance and greatly enhance test safety, efficiency, and effectiveness.

2. The United States Army Aviation Systems Test Activity (USAASTA) initiated Project No. 68-22 to establish requirements for the external stores jettison envelopes of rotary wing vehicles. The report (ref 1, app A) recommended that the minimum demonstrated envelope should be that which the pilot recognizes as coordinated flight. Side force was found to be the primary cue the pilot could use to sense uncoordinated flight. This side force is generated by the dihedral effect which introduces a bank angle when the aircraft is experiencing a sideslip. The dihedral effect is different for each aircraft and for a given aircraft can change with operating conditions such as gross weight, rotor speed, altitude, and airspeed. Results suggested that the pilot recognition of the side force was independent of all factors and that an acceleration of 0.1g was sensed by all pilots, regardless of aircraft type.

3. United States Army Aviation Systems Command test directive 71-03 (ref 2, app A) requested that USAASTA perform a follow-on to Project No. 68-22 to include other helicopter types and configurations and to expand upon the results previously obtained.

TEST OBJECTIVES

4. The overall objective of this test was to verify the general nature of the side-force characteristics in various aircraft and to determine the advisability of using side force as a jettison envelope criterion. Specific objectives include:

a. Obtain sideslip recognition data from different aircraft at various operating conditions.

b. Confirm that side force is the most significant pilot cue for recognizing uncoordinated flight for all helicopter types and configurations.

c. Verify that the pilot can use side force to determine when coordinated flight is achieved after a dynamic maneuver from an uncoordinated condition.

d. Develop a procedure whereby jettison envelope requirements can be determined from pilot recognition of uncoordinated flight and aircraft lateral-directional stability characteristics.

e. Compare actual jettison envelopes with those determined by use of this new procedure.

DESCRIPTION

5. Test aircraft used were an OH-58A helicopter, S/N 68-16706, an OH-6A helicopter, S/N 69-16063, and an AH-56A helicopter, S/N 66-8834. Detailed descriptions of these aircraft are contained in references 3, 4, and 5, appendix A.

SCOPE OF TEST

6. The OH-6A and OH-58A tests were conducted at Edwards Air Force Base, California, from 5 October to 5 December 1972. These tests required a total of 5 flights for 4.5 productive test hours. The AH-56A tests were conducted at Yuma Proving Ground, Arizona, on 26 February 1971 in conjunction with other tests. Limitations in the operator's manual (refs 3, 4, and 5, app A) were observed. Testing of each aircraft was also limited to the clean configuration.

7. Data were obtained by four pilots during the evaluation. Previous flight test results for the AH-1G, OH-6A, and OH-58A were examined to analytically establish trends of side-force characteristics with changes in gross weight, altitude, rotor speed, airspeed, and center-of-gravity (cg) location. It was intended to test the AH-1G; however, time constraints and lack of an instrumented aircraft prevented accomplishing this objective.

METHODS OF TEST

8. Steady-state level and autorotational flights were performed at various airspeeds to establish pilot recognition cues of uncoordinated flight. Recognizable sideslip angles were established by increasing sideslip from a trim, wings-level condition, and then recording data upon the pilot's first impression of uncoordinated flight. The effects of returning from uncoordinated flight on pilot cues were determined by starting at a high-sideslip out-of-trim condition, and then decreasing the sideslip angle. Data were recorded when the pilot had the impression he was in coordinated flight. Sideslip was measured by a vane mounted on the nose boom and side force was obtained from instruments located near the aircraft cg.

9. Data for the evaluation of atmospheric conditions and helicopter loadings on the side-force gradient, $d\phi/d\beta$, were obtained from references 6, 7, and 8, appendix A. From the static lateral-directional stability data, a statistical analysis was applied to the variation of roll attitude with sideslip as a function of calibrated airspeed. The analysis consisted of applying a regression analysis to the $d\phi/d\beta$ versus airspeed data and testing the goodness of fit with the correlation coefficient for the calculated function. A detailed discussion of the statistical analysis procedure is presented in appendix B. Calibrated instrumentation was used for all testing. Data were recorded on automatic recording devices in each aircraft.

CHRONOLOGY

10. The chronology of testing is as follows:

Test directive received	25	January	1971
AH-56A testing	26	February	1971
OH-58A testing started	5	October	1972
OH-58A testing completed	6	October	1972
OH-6A testing started	31	October	1972
OH-6A testing completed	5	December	1972

RESULTS AND DISCUSSION

GENERAL

11. This report represents a follow-on study to Project No. 68-22, *Rotary Wing Vehicle External Stores Jettison Envelope Pilot Established Requirements* (ref 1, app A). Results of that report are summarized in appendix C.

12. The most recognizable cue for uncoordinated flight is side force. For all the test aircraft and flight conditions evaluated, uncoordinated flight was recognized by all pilots within the 0.1g side-force criterion. It was also demonstrated that the same side-force criterion is valid when going from uncoordinated to coordinated flight conditions.

13. A combination of the side-force recognition factor of 0.1g, the side-force gradient, and the inherent sideslip characteristics of the aircraft can be used to establish the minimum required jettison envelope for any helicopter. Studies of the previously obtained side-force characteristics of the OH-6A, OH-58A, and AH-1G show no significant trends with respect to atmospheric conditions or helicopter loading. The procedure can use flight test data or theoretical data to predict the envelope. When the stores or aircraft geometry are known, theory, wind tunnel, or flight test can be used to demonstrate the jettison capability. Wind tunnel data or theory resulting in unsuccessful stores separation can provide early guidance concerning the need for forced separation of the stores.

PILOT RECOGNITION CUE

14. The ability of a pilot to determine uncoordinated flight by physical cues was evaluated on the OH-6A, OH-58A, and AH-56A helicopters. With the exception of the AH-56A, each aircraft was flown by two different pilots, and the project pilot flew both the OH-58A and OH-6A. Test results are presented in figures 1 through 3, appendix D.

15. The data correspond to the pilot's first impression of an uncoordinated condition in level flight and autorotation. Uncoordinated flight for the different pilots, aircraft, and conditions was recognized at a side force of less than 0.05g. The close grouping of the side-force data indicates that the recognition cue was essentially unaffected by changing aircraft, with little variation between pilots. It also demonstrates the high repeatability of the side-force cue and places a high confidence factor on using it to define the envelope. The recognition level was the same in autorotation as in level flight.

16. The initial side-force cue data were obtained by increasing side force from an initial wings-level condition. However, the aircraft may be in an uncoordinated condition when the need to jettison arises. The pilot perception of sideslip must

also apply in this situation. That is, during return from an out-of-trim condition to a coordinated condition the pilot recognition of zero side force should occur at a sideslip near to the originally perceived value. This criterion was met in all test cases.

17. The data were examined for any bias caused by the pilot's knowledge of the experiment design and the nature of the recognition signal. It was expected that pilot performance would be optimum under these conditions. Although the results of this evaluation alone indicate a lower side-force criterion, previous test results of other aircraft under more extensive test maneuvers proved that the 0.1g side force was more valid.

SIDE-FORCE GRADIENT

18. The side-force gradient, $d\phi/d\beta$, is the variation of roll attitude with sideslip angle. This characteristic provides the side force felt by the pilot when in an out-of-trim condition. The pilot perceived jettison envelope is based on a side force of 10 percent of the normal g force (ref 1, app A), and in level flight is equivalent to a 5.7-degree roll attitude.

19. Data from reports on the AH-1G, OH-58A, and OH-6A helicopters (refs 6, 7, and 8, app A) were analyzed to determine if $d\phi/d\beta$ was independent of ambient condition and loading. The results are presented in figures 4 through 6, appendix D. As indicated, a wide range of aircraft conditions were compared.

20. A statistical curve fit was applied to each set of aircraft data to determine if a single function could represent the relationship of $d\phi/d\beta$ with respect to calibrated airspeed. The curve fit for the AH-1G helicopter had a correlation coefficient of .9671, defining 93.5 percent of the population. The OH-6A and the OH-58A helicopters had correlation coefficients of .9795 and .9809, defining 95.9 and 96.2 percent of their respective sets of data. The high degree of correlation indicates the relation of $d\phi/d\beta$ and calibrated airspeed can be defined by a single function.

21. The results of the statistical analysis indicate that, within the scope of this evaluation, side-force gradient is dependent on calibrated airspeed and is essentially independent of ambient conditions and helicopter loading. Therefore, one $d\phi/d\beta$ curve is applicable to all state conditions for a given aircraft. Configuration changes for a given aircraft can alter aerodynamics and stability characteristics to such an extent that each configuration must be considered independently.

INHERENT SIDESLIP CHARACTERISTICS

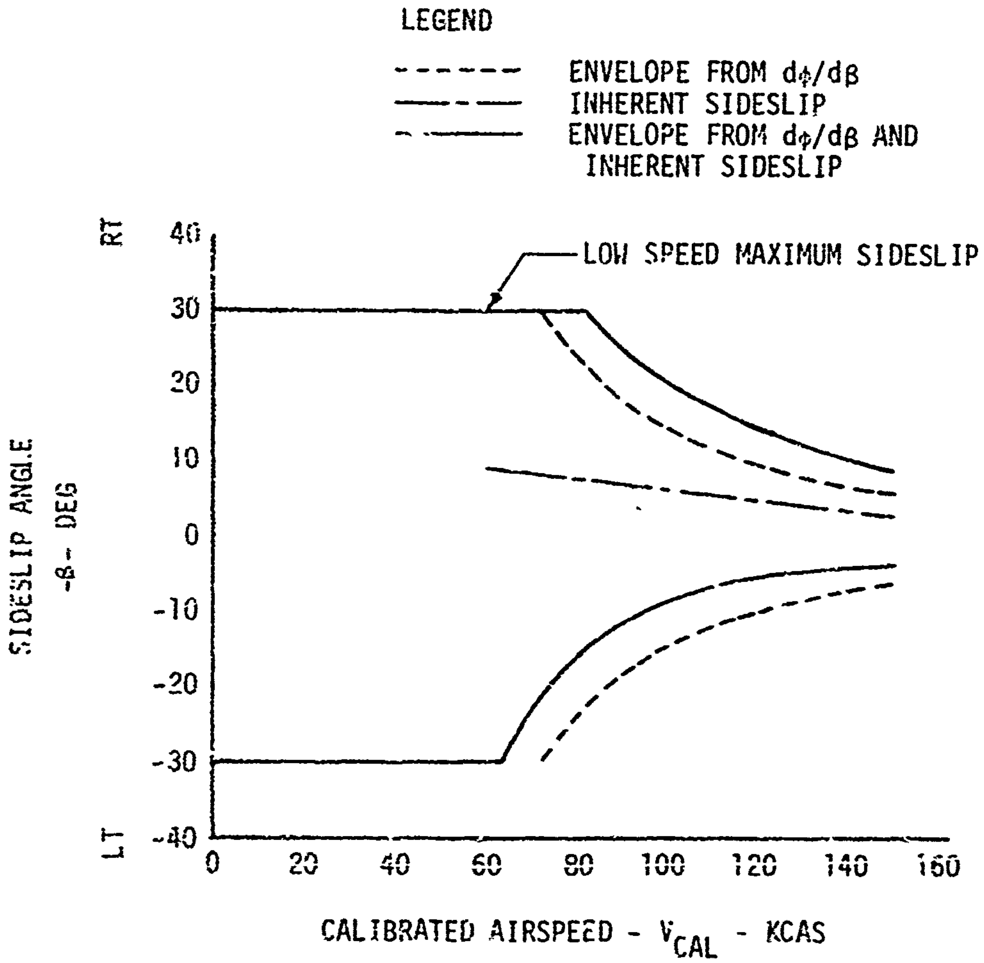
22. Normally, a tail rotor helicopter flies with an inherent sideslip during straight and level, ball-centered flight. Inherent sideslip is then defined as the sideslip angle when roll attitude is zero. In most cases, this inherent sideslip is a right sideslip,

which is greatest at low speeds and decreases as speed is increased. Inherent sideslip characteristics for the AH-1G, OH-58A, and OH-6A helicopters are presented in figures 4, 5, and 6, appendix D. The inherent sideslip for the OH-6A is unusual in that it is essentially a constant 2- to 3-degree left sideslip throughout the flight envelope. The inherent sideslip characteristics for the AH-56A varied significantly between modifications and are not presented.

23. Inherent sideslip has no effect on the side-force gradient. The effect is to translate the jettison envelope to a nonsymmetrical sideslip variation about zero. A typical sideslip jettison envelope is shown in figure A. The sideslip limits are first determined from the side-force gradient, $d\phi/d\beta$, giving a sideslip jettison envelope as shown. When inherent sideslip is introduced, the envelope is shifted to the right. The combination of side-force gradient and inherent sideslip forms the sideslip jettison envelope.

FIGURE A

TYPICAL SIDESLIP JETTISON ENVELOPE



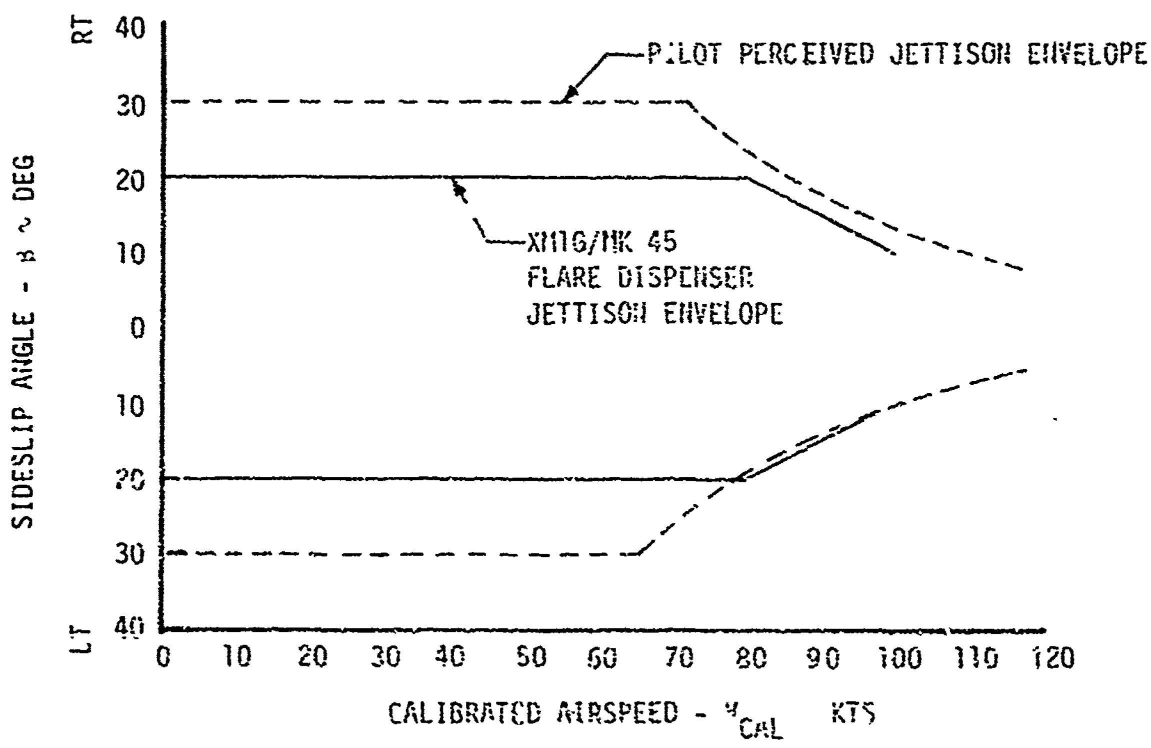
COMPARISON WITH TEST JETTISON ENVELOPES

24. The jettison envelope of an XM19/MK45 flare dispenser from a UH-1C helicopter was established by actual jettisons of the store at various airspeeds and sideslip angles. The trajectory of the jettisoned store was then the resultant of the store aerodynamics, aircraft attitude, and airflow around the helicopter. A jettison was considered successful when the jettisoned store missed the helicopter. This envelope demonstrates the actual jettison capability of the aircraft system. An envelope was then calculated using the 0.1g side-force criterion and compared with the test jettison envelope (ref 9, app A) in figure B. The two envelopes are quite similar in the high-speed range, with a larger envelope required at low speeds for the calculated jettison envelope. The most significant aspect of the comparison is that the actual tested envelope is smaller than that required on the basis of pilot recognition of uncoordinated flight. In this case the pilot could believe he was in coordinated flight, jettison the store, and have it strike the aircraft. At present, he must observe cockpit gages to ensure that he is within the jettison envelope. Other solutions include changing the side-force characteristics or incorporating forced jettison of the stores. Eight jettisons in forward flight were required to establish the XM19/MK45 flight test envelope. A calculation on the basis of the side-force criterion would have quickly set the boundaries of the envelope which could have been verified with a smaller number of test points.

FIGURE B

COMPARISON OF UH-1C JETTISON ENVELOPES

NOTE: PILOT PERCEIVED JETTISON ENVELOPE BASED ON UH-1C d_ϕ/d_β AND INHERENT SIDESLIP.



DETERMINATION OF JETTISON ENVELOPE

25. Aircraft characteristics of side-force gradient and inherent sideslip may be determined from theory, wind tunnel, or handling qualities evaluations. Calculations are then made to establish an envelope on the basis of pilot recognition of uncoordinated flight. The sideslip resultant angles, stores geometry, and aerodynamics can then be used to compare with the estimated jettison capability. Weak static lateral-directional stability characteristics will increase the sideslip angles required for recognition and lead to complications when aircraft/external stores clearance is a critical factor. This evaluation should quickly point out the need for a force jettison system or hardware redesign. Following the analysis, actual jettison of stores would be conducted at a sufficient number of conditions to verify that the stores can be successfully jettisoned at the predetermined jettison envelope limits. This procedure puts establishment of jettison envelopes for external stores on a sound engineering approach, and ensures compatibility of pilot sideslip recognition requirements and system capability, as well as reducing test hazards and costs.

26. In order to determine the required pilot perceived jettison envelope of the aircraft, the side-force gradient and the inherent sideslip characteristics must be known. A procedure for determining the envelope, given these parameters, is illustrated in figure C. The arrows indicate the procedure for determining the envelope. The envelope may also be analytically calculated by the following procedure:

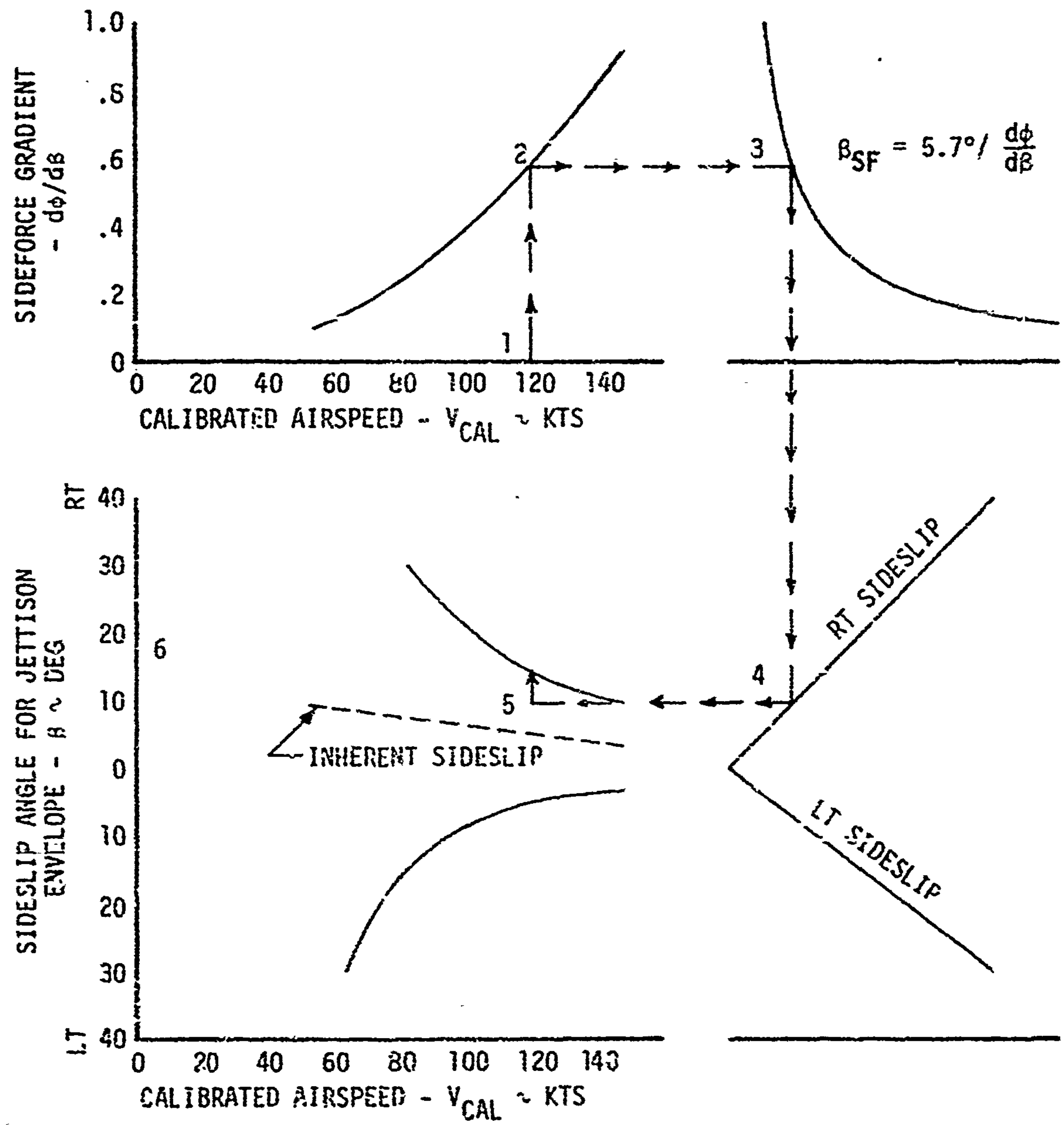
$$\beta_{SF} = 5.7\text{deg}/d\phi/d\beta \qquad (1)$$

$$\beta = \beta_{SF} + \beta_I \qquad (2)$$

27. The sideslip (β_{SF}) is calculated from equation 1 at a specific airspeed. The inherent sideslip (β_I), corresponding to the same airspeed, is then added in equation 2, to form th envelope sideslip. The procedure is repeated for a series of airspeeds, resulting in sideslip as a relation of airspeed, and forming the pilot perceived jettison envelope. A maximum sideslip limit of 30 degrees is applied at the slower speeds, as recommended in reference 1, appendix A.

FIGURE C
GRAPHICAL REPRESENTATION OF
SIDESLIP JETTISON ENVELOPE

NOTES:
1. ENTER AT CALIBRATED AIRSPEED
2. GO TO SIDEFORCE CHARACTERISTIC
3. GO TO 10% OF 1 G CRITERIA
4. GO TO SIDESLIP DIRECTION
5. ADD INHERENT SIDESLIP ANGLE
6. READ SIDESLIP JETTISON ANGLE



CONCLUSIONS

28. The following conclusions were reached upon completion of testing.

a. Pilot recognition of uncoordinated flight was within a maximum side-force value of 0.1g for all pilots and all aircraft tested (para 15).

b. The side-force recognition cue is valid for recognizing development of uncoordinated flight or for return to trimmed flight (para 16).

c. Data obtained during this evaluation showed that the pilots recognized a weaker side-force cue than was recorded by the pilots in the initial tests (para 17).

d. Within the scope of this evaluation, side-force gradient is dependent only on calibrated airspeed (para 21).

e. The derived jettison envelope must include the effects of inherent sideslip (para 23).

f. Comparison of an actual jettison envelope with one calculated on the basis of a pilot recognition of 0.1g side force shows the pilot perception criteria to be more critical (para 24).

g. Incorporating aircraft stability characteristics, pilot recognition of side-force cue, and external stores characteristics into a test procedure can produce a jettison envelope with a minimum of time, cost, and risk (para 25).

RECOMMENDATIONS

29. A side-force cue of 0.1g should be used for pilot requirements in determining jettison envelopes.

30. All jettisonable stores should be designed in accordance with the criterion that successful jettison be possible at all sideslip angles within the pilot perceived jettison envelope as defined in this report.

31. Jettisonable stores which fail to meet the above design requirement by analysis of wind tunnel tests should be modified prior to actual flight testing.

32. Future jettison flight tests should employ the methodology described in this report.

APPENDIX A. REFERENCES

1. Final report, USAASTA, Project No. 68-22, *Rotary Wing Vehicle External Stores Jettison Envelope, Pilot Established Requirements*, August 1970.

2. Letter, AVSCOM, AMSAV-R-F, 25 January 1971, subject: Pilot Perceived Jettison Envelope, Project No. 71-03.

3. Technical Manual, TM 55-1520-228-10, *Operator's Manual, Army Model OH-58A Helicopter*, 13 October 1970.

4. Technical Manual, TM 55-1520-214-10, *Operator's Manual, Army Model OH-6A Helicopter*, 7 December 1967.

5. Preliminary Operational/Maintenance Manual, POMM 15-1520-222-10, *Operator's Manual, Helicopter, Attack, AH-56A (Lockheed)*, July 1971.

6. Final Report, USAASTA, Project No. 66-06, *Engineering Flight Test, AH-1G Helicopter (HueyCobra), Phase D, Part 1, Handling Qualities*, December 1970.

7. Final Report, USAASTA, Project No. 68-30, *Airworthiness and Flight Characteristics Test, Production OH-58A Helicopter, Unarmed and Armed with XM27E1 Armament Subsystem, Stability and Control*, October 1970.

8. Final Report, USAASTA, Project No. 65-37, *Engineering Flight Test of the OH-6A Helicopter (Cayuse), Phase D*, April 1969.

9. Final Report, USAASTA, Project No. 69-07, *Jettison Test, XM19/MK 45 Flare Dispenser Installed in the UH-1C Helicopter*, December 1969.

APPENDIX B. STATISTICAL ANALYSIS METHOD

1. Given a linear function of two variables represented by normally distributed observations (population), a first-order regression analysis can be applied to the sample of data. This linear regression defines the best straight line which represents the data. The regression analysis also provides indicators as to the goodness of fit, verifying or disproving the relation between the two variables. The equation is of the form:

$$Y = AX + B \tag{1}$$

Where Y is the dependent variable, X is the independent variable, A the regression coefficient, and B a constant. The sample correlation coefficient is an indication of the fraction of Y variance accounted for by the regression of Y on X. The square of the correlation coefficient indicates the percentage of the population defined by the regression equation.

2. The relation between the side-force gradient $d\phi/d\beta$ and airspeed is nonlinear, and was determined to be of exponential form. In order to statistically analyze the variation of $d\phi/d\beta$ with airspeed, the relation had to be modified to a linear form. An exponential curve fit of the form

$$Y = Be^{AX} \tag{2}$$

can be analyzed as a linear regression with the following modification. Taking the natural log of the equation

$$\ln (Y) = \ln (be^{AX}) \tag{3}$$

$$\ln (Y) = \ln (B) + AX \tag{4}$$

Equation 4 is of identical form to equation 1, and therefore can be analyzed to determine the goodness of fit with the above techniques.

APENDIX C. SUMMARY RESULTS, PROJECT NO.68-22

1. The concept of a pilot perceived jettison envelope was established in Project No. 68-22, *Rotary Wing Vehicle External Stores Jettison Envelope Pilot Established Requirements* (ref 1, app A). A brief summary of the results of this report is presented to provide a background of information on the development of this concept.

2. A jettison envelope establishes the conditions for which an external store may be jettisoned from the helicopter. Previous tests have shown that an acceptable jettison envelope is based primarily on stores configurations, airspeed, angles of sideslip and attack, and basic flying qualities of the helicopter. Of these, the pilot can most easily control sideslip, which is the most significant with respect to the jettison envelope. The minimum envelope for jettison should be that in which the pilot is under the impression he is in coordinated flight, thereby introducing a pilot perceived jettison envelope.

3. The primary pilot cue for recognizing uncoordinated flight is side force. This is a valid cue in both steady and maneuvering flight. A side force of 10 percent of normal g force was recognizable by all pilots as a cue for uncoordinated flight. At low speeds, greater sideslip angles are required to produce the recognizable 0.1g side force. This sideslip angle becomes so large that the visible sideslip is the first recognizable pilot cue. Also, sideslip excursions in high-g, high-airspeed, ball-centered maneuvers greater than the established jettison envelopes were encountered.

4. The side-force recognition factor can be analyzed in terms of an aircraft stability parameter. This parameter (side-force characteristic) is the incremental change in roll angle with sideslip angle, $d\phi/d\beta$. The side-force recognition factor of 10 percent of a g amounts to a change in bank angle from trim of 5.7 degrees. The curve β = (5.7 degrees) / $(d\phi/d\beta)$, establishes the sideslip limits for recognition of coordinated flight. The sideslip jettison envelope with β as a function of airspeed is derived from this.

APPENDIX D. TEST DATA

FIGURE 1

PILOT RECOGNITION OF UNCOORDINATED FLIGHT

OH-58A USA S/N 68-16706

CLEAN CONFIGURATION
LEVEL FLIGHT
CENTER OF GRAVITY LOCATION = 108.0 (FWD)

SYMBOL	DENSITY ALTITUDE $-H_D \sim$ FT	AMBIENT AIR TEMP $-T_a \sim$ DEG C	ROTOR SPEED $-N_R \sim$ RPM	GROSS WT GW ~ LB	PILOT
○	5100	16.0	351	2800	PROJECT PILOT
□	4900	19.0	351	2790	SECOND PILOT

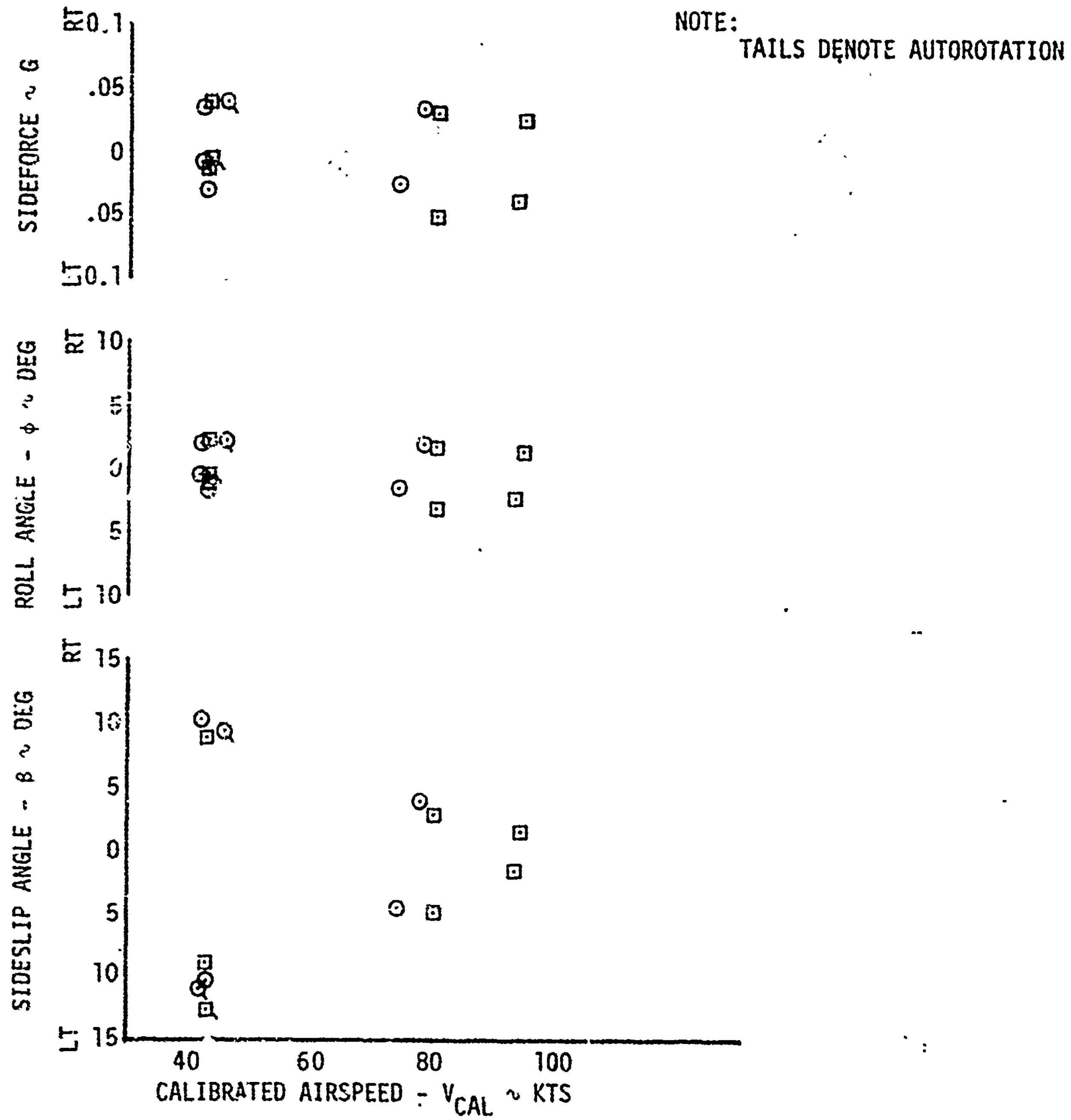


FIGURE 2

PILOT RECOGNITION OF UNCOORDINATED FLIGHT

OH-6A USA S/N 69-16063

CLEAN CONFIGURATION

LEVEL FLIGHT

CENTER OF GRAVITY LOCATION = 97.0 (FWD)

SYMBOL	DENSITY ALTITUDE $-H_D \sim$ FT	AMBIENT AIR TEMP $-T_a \sim$ DEG C	ROTOR SPEED $-N_R \sim$ RPM	GROSS WT GW ~ LB	PILOT
○	3000	-1.0	476	2350	PROJECT PILOT
□	4150	10.0	476	2280	SECOND PILOT

NOTE:
TAILS DENOTE AUTOROTATION

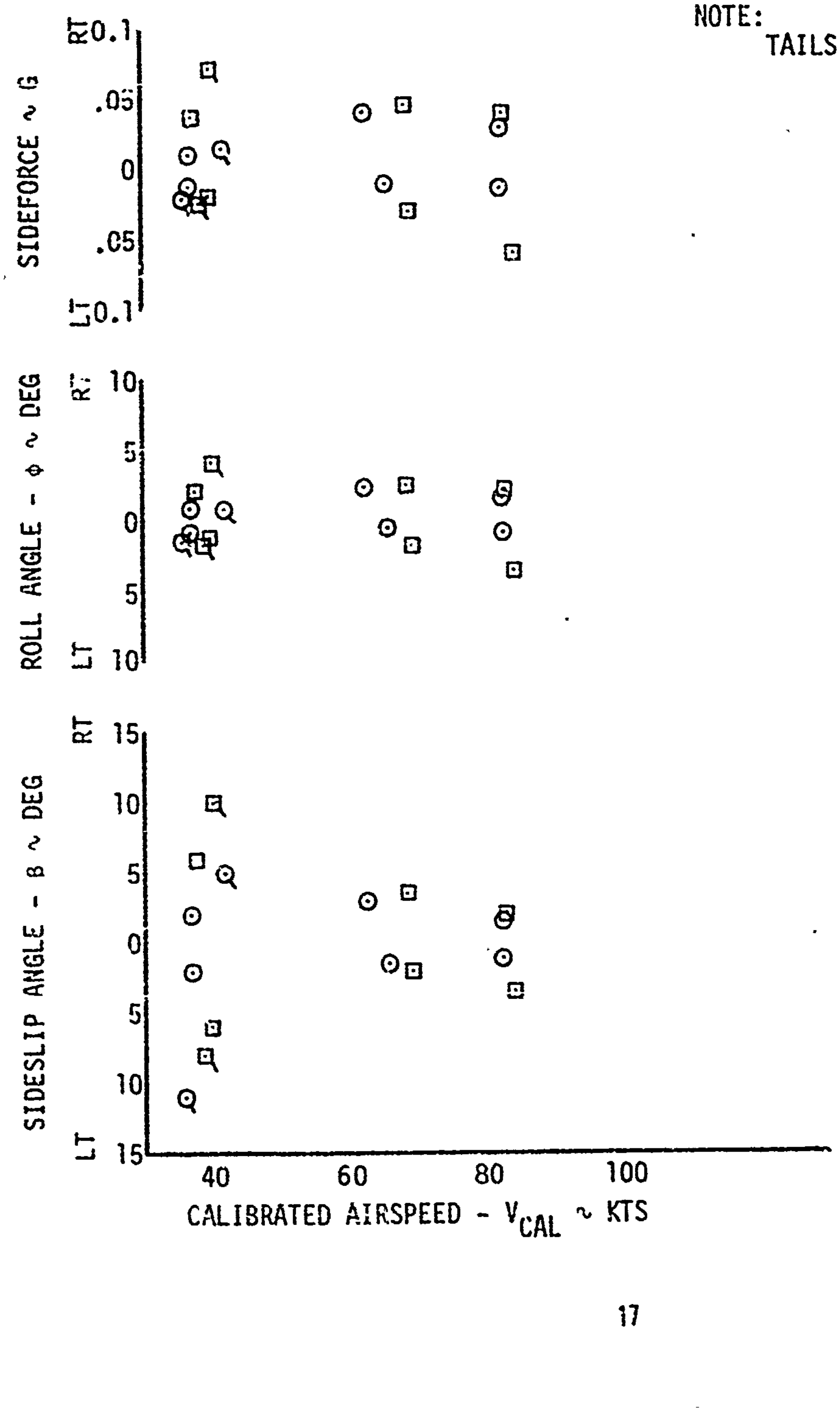


FIGURE 3

PILOT RECOGNITION OF UNCOORDINATED FLIGHT

AH-56A USA S/N 66-8834

CLEAN CONFIGURATION

LEVEL FLIGHT

CENTER OF GRAVITY LOCATION = 299.5 (MID)

DENSITY ALTITUDE $-H_D$ ~ FT	AMBIENT AIR TEMP $-T_a$ ~ DEG C	ROTOR SPEED $-N_R$ ~ RPM	GROSS WT GW ~ LB
4300	14.0	246	18000

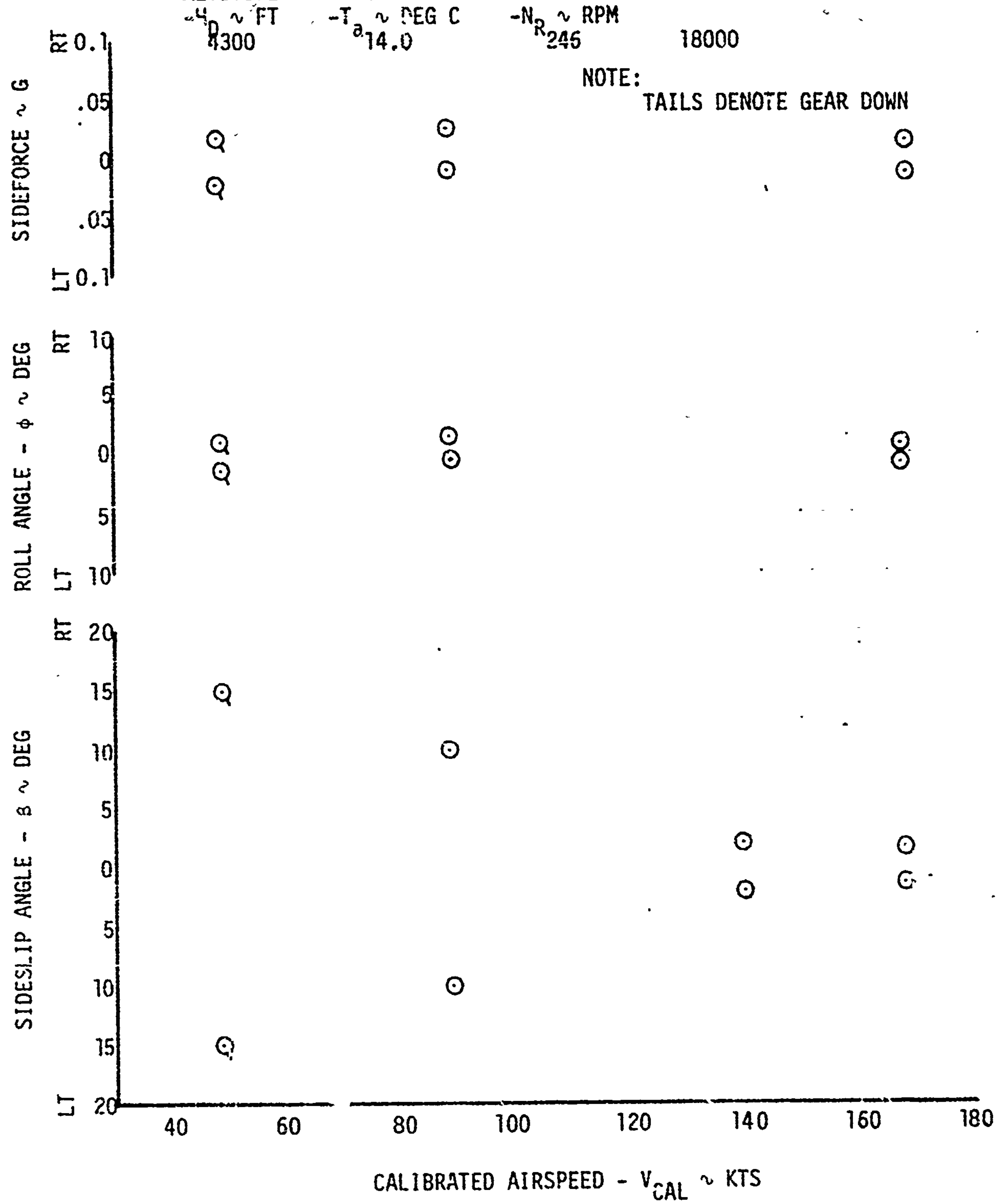


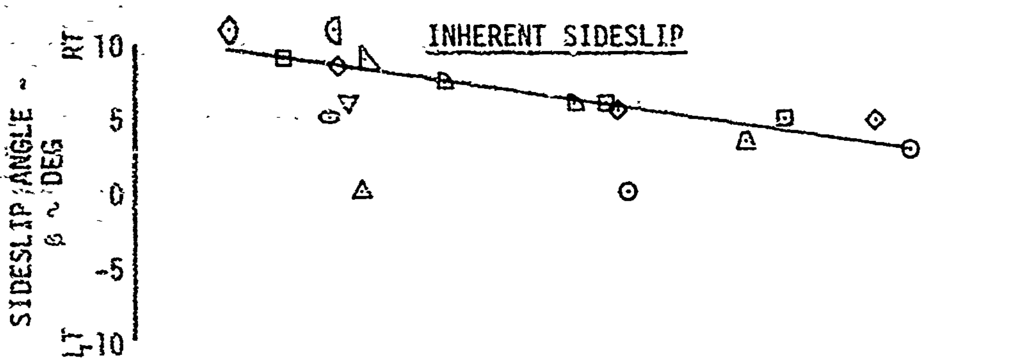
FIGURE 4

LATERAL-DIRECTIONAL CHARACTERISTICS

AH-1G USA S/N 715695

HVY. HOG CONFIGURATION WITH ROCKET POD FAIRINGS REMOVED

SYMBOL	AVG GROSS WEIGHT ~LB	AVG DENSITY ALTITUDE ~FT	AVG LONG. CG ~IN	ROTOR SPEED ~RPM	AVG THRUST COEFFICIENT	FLIGHT CONDITION
○	7840	3870	201.3(AFT)	324	.004363	LEVEL FLIGHT
□	8580	4650	200.8(AFT)	323	.004913	LEVEL FLIGHT
◇	9620	4610	199.9(AFT)	323	.005502	LEVEL FLIGHT
▷	8580	14300	200.7(AFT)	324	.006615	LEVEL FLIGHT
△	8090	6310	191.1(FWD)	324	.004851	LEVEL FLIGHT
△	7530	7890	201.4(AFT)	310	.005182	AUTO DESCENT
⬭	7980	8770	200.9(AFT)	328	.005038	AUTO DESCENT
◺	9190	6930	199.9(AFT)	323	.005652	AUTO DESCENT
▽	7530	3490	204.4(AFT)	323	.004197	CLIMB
◖	9350	4580	199.9(AFT)	316	.005593	CLIMB
◇	8300	15650	200.7(AFT)	324	.006695	CLIMB



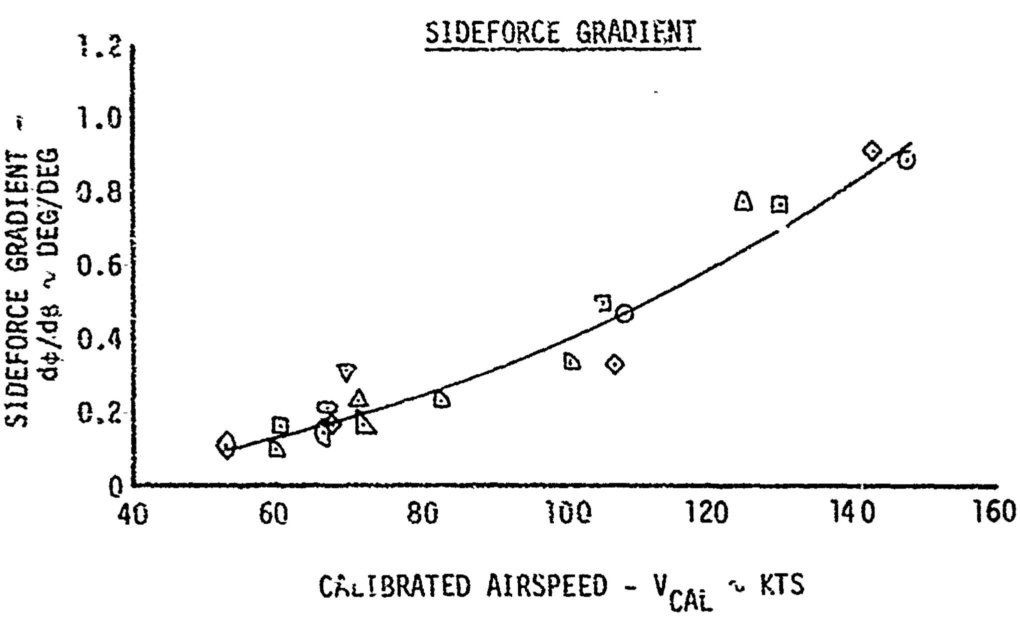


FIGURE 5
LATERAL-DIRECTIONAL CHARACTERISTICS
OH-58A USA S/N 68-16706
ARMED CONFIGURATION

SYMBOL	AVG GROSS WEIGHT ~LB	AVG DENSITY ALTITUDE ~FT	AVG LONG. CG ~IN	ROTOR SPEED ~RPM	AVG THRUST COEFFICIENT	FLIGHT CONDITION
○	2660	1660	105.7(FWD)	354	.002793	LEVEL FLIGHT
□	2620	5980	107.0(FWD)	354	.003140	LEVEL FLIGHT
◇	2650	14920	107.1(FWD)	354	.004201	LEVEL FLIGHT
△	2910	6020	105.9(FWD)	354	.003488	LEVEL FLIGHT
◺	2910	5930	112.0(AFT)	354	.003485	LEVEL FLIGHT
△	2610	5890	106.8(FWD)	354	.003126	AUTO DESCENT
⬭	2610	5890	106.8(FWD)	354	.003126	CLIMB

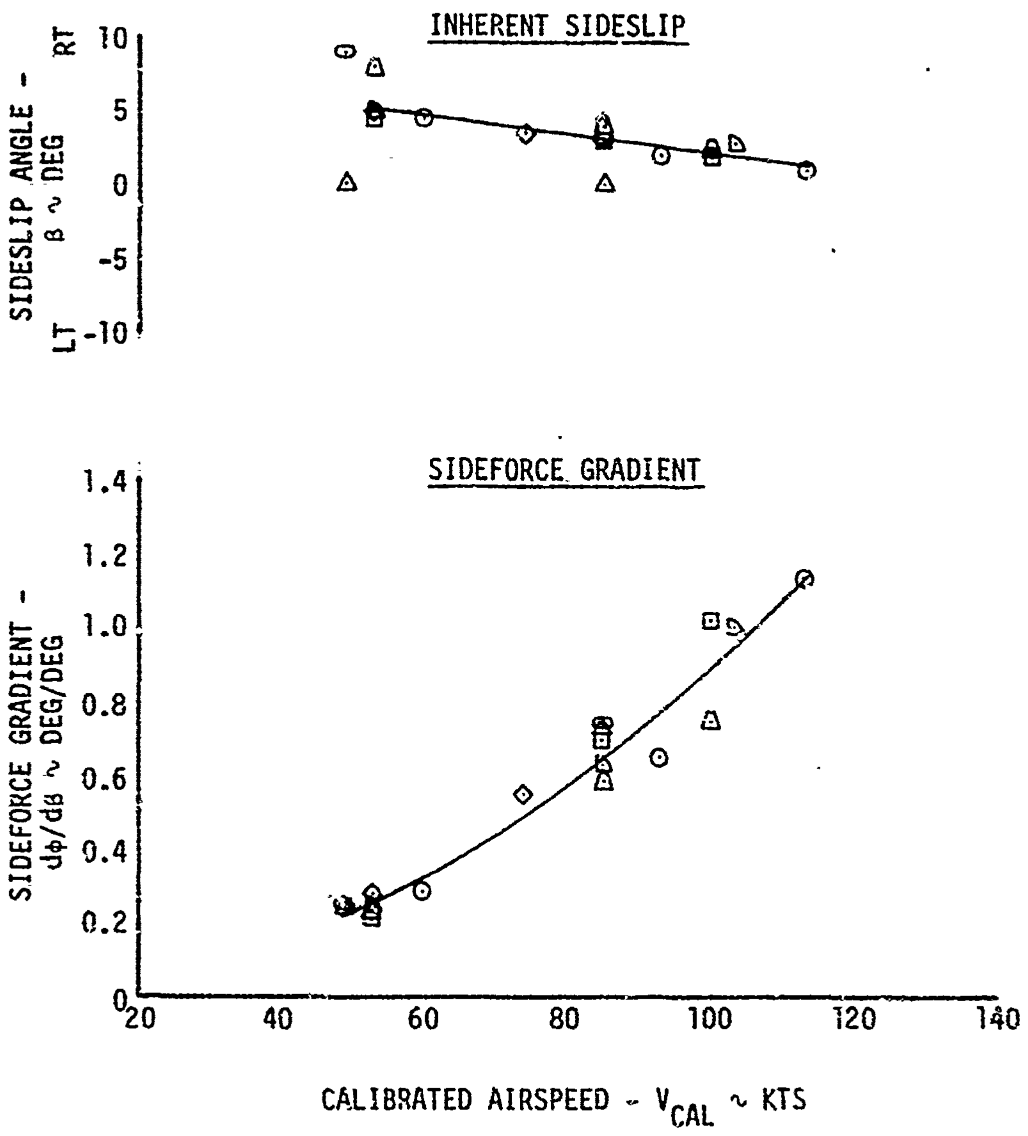


FIGURE 6

LATERAL-DIRECTIONAL CHARACTERISTICS

OH-6A USA S/N 65-12919

CLEAN CONFIGURATION

LEVEL FLIGHT

SYMBOL	AVG GROSS WEIGHT ~LB	AVG DENSITY ALTITUDE ~FT	AVG LONG. CG ~IN	ROTOR SPEED ~RPM	AVG THRUST COEFFICIENT
○	2370	5140	97.2(FWD)	483	.004800
□	2320	-320	104.0(AFT)	483	.004003
◇	2310	10080	103.0(AFT)	483	.005456
▷	2140	5120	100.0(MID)	483	.004338
△	2400	4930	99.3(MID)	483	.004835
△	2050	50	97.0(FWD)	483	.003578
⬭	2370	-60	97.0(FWD)	483	.004111